Regional Operational Plan SF.4A.2014.08

Estimation and Projection of Statewide Recreational Halibut Harvest

by

Scott C. Meyer

October 2014

Alaska Department of Fish and Game **Divisions of Sport Fish and Commercial Fisheries**

Symbols and Abbreviations

The following symbols and abbreviations, and others approved for the Système International d'Unités (SI), are used without definition in the following reports by the Divisions of Sport Fish and of Commercial Fisheries: Fishery Manuscripts, Fishery Data Series Reports, Fishery Management Reports, and Special Publications. All others, including deviations from definitions listed below, are noted in the text at first mention, as well as in the titles or footnotes of tables, and in figure or figure captions.

Weights and measures (metric)	
centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
milliliter	mL
millimeter	mm
Weights and measures (English)	
cubic feet per second	ft^3/s
foot	ft
gallon	gal
inch	in
mile	mi
nautical mile	nmi
ounce	oz
pound	lb
quart	qt
yard	yd
Time and temperature	
day	d
degrees Celsius	°C
degrees Fahrenheit	°F
degrees kelvin	K
hour	h
minute	min
second	s
Physics and chemistry	
all atomic symbols	
alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
hydrogen ion activity (negative log of)	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

General	
Alaska Administrative Code	AAC
all commonly accepted abbreviations	e.g., Mr., Mrs., AM, PM, etc.
all commonly accepted professional titles	e.g., Dr., Ph.D., R.N., etc.
at	@
compass directions:	
east	E
north	N
south	S
west	W
copyright	©
corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
District of Columbia	D.C.
et alii (and others)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.
Federal Information Code	FIC
id est (that is)	i.e.
latitude or longitude	lat or long
monetary symbols (U.S.)	\$, ¢
months (tables and figures): first three letters	Jan,...,Dec
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S.C.	United States Code
U.S. state	use two-letter abbreviations (e.g., AK, WA)

Mathematics, statistics	
all standard mathematical signs, symbols and abbreviations	
alternate hypothesis	H_A
base of natural logarithm	*e*
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	(F, t, χ^2, etc.)
confidence interval	CI
correlation coefficient (multiple)	R
correlation coefficient (simple)	r
covariance	cov
degree (angular)	°
degrees of freedom	df
expected value	*E*
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	$\log_{2}$, etc.
minute (angular)	'
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
variance	
population	Var
sample	var

REGIONAL OPERATIONAL PLAN SF.4A.2014.08

ESTIMATION AND PROJECTION OF STATEWIDE RECREATIONAL HALIBUT HARVEST

by

Scott C. Meyer

Alaska Department of Fish and Game, Division of Sport Fish, Homer

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Division of Sport Fish

October 2014

The Regional Operational Plan Series was established in 2012 to archive and provide public access to operational plans for fisheries projects of the Divisions of Commercial Fisheries and Sport Fish, as per joint-divisional Operational Planning Policy. Documents in this series are planning documents that may contain raw data, preliminary data analyses and results, and describe operational aspects of fisheries projects that may not actually be implemented. All documents in this series are subject to a technical review process and receive varying degrees of regional, divisional, and biometric approval, but do not generally receive editorial review. Results from the implementation of the operational plan described in this series may be subsequently finalized and published in a different department reporting series or in the formal literature. Please contact the author if you have any questions regarding the information provided in this plan. Regional Operational Plans are available on the Internet at: http://www.adfg.alaska.gov/sf/publications/

Scott C. Meyer,
Alaska Department of Fish and Game, Division of Sport Fish,
3298 Douglas Place, Homer, AK 99603

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Title	Name	Signature	Date
Project leader	Scott Meyer	Scott Meyer	9/11/2014
Biometrician	Adam Craig	AC	9/12/2014
Research Coordinator		James J. Hasbrouck	9/15/2014
Regional Supervisor	James Hasbrouck	James J. Hasbrouck	9/15/2014

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PURPOSE

This plan describes the procedures by which multiple types of halibut sport fishery data from the Alaska Department of Fish and Game Statewide Harvest Survey, creel sampling programs, and charter logbook will be synthesized to provide estimates and projections of guided and unguided recreational halibut harvest and discard mortality for Alaska. This information is provided annually to multiple federal agencies for halibut stock assessment, development of harvest policy, and evaluation of annual management measures for the guided recreational halibut fishery.

BACKGROUND

The marine waters of Southeast and Southcentral Alaska support a major recreational fishery for Pacific halibut *Hippoglossus stenolepis*. Recreational harvest of halibut has grown considerably since the mid-1970s. Skud (1975) estimated the entire Alaska sport harvest at 10,000 fish in the mid-1970s. Estimates from the ADF&G Sport Fish Survey, or "Statewide Harvest Survey" (SWHS), range from about 23,000 fish statewide when the survey began in 1977 to a peak harvest of nearly 585,000 halibut in 2007 (Figure 1). The majority of the recreational harvest occurs in that portion of Southcentral Alaska making up International Pacific Halibut Commission (IPHC) Regulatory Area 3A, which stretches from Cape Spencer to the south end of Kodiak Island (Figure 2). Most of the remainder of the sport harvest occurs in Area 2C, which extends from Cape Spencer to the southern border of Southeast Alaska near Ketchikan. Sport harvest is relatively minor in Areas 3B and 4 (Figure 1). The halibut fishery and related tourism are extremely important to the economy of coastal communities, providing significant seasonal employment and income.

A number of jurisdictions and agencies are involved in halibut management. The fishery is managed under the "Convention Between the United States and Canada for the Preservation of the Halibut Fishery of the North Pacific Ocean and Bering Sea" (Convention). Within the United States, the IPHC and National Marine Fisheries Service (NMFS) manage halibut under authority of the Northern Pacific Halibut Act of 1982 (Halibut Act). The Secretary of Commerce has authority to approve regulations necessary to carry out the objectives of the Convention and Halibut Act. In addition, the North Pacific Fishery Management Council (Council) has authority to develop additional regulations for allocation of the halibut resource within Alaska. These regulations may not be in conflict with IPHC regulations. The ADF&G Commissioner is a designated voting member of the Council, and represents the state's interests in allocation and management decisions.

Since the mid-1980s, ADF&G has assumed responsibility for collection of data from the recreational fishery in order to advise federal management agencies such that decisions could be made based upon the best available information. ADF&G provides the IPHC with harvest information annually for stock assessments, formulation of harvest strategies, and to aid in apportionment of quota recommendations among regulatory areas. ADF&G also provides this information to the Council and analyzes regulatory alternatives for management of the sport charter sector.

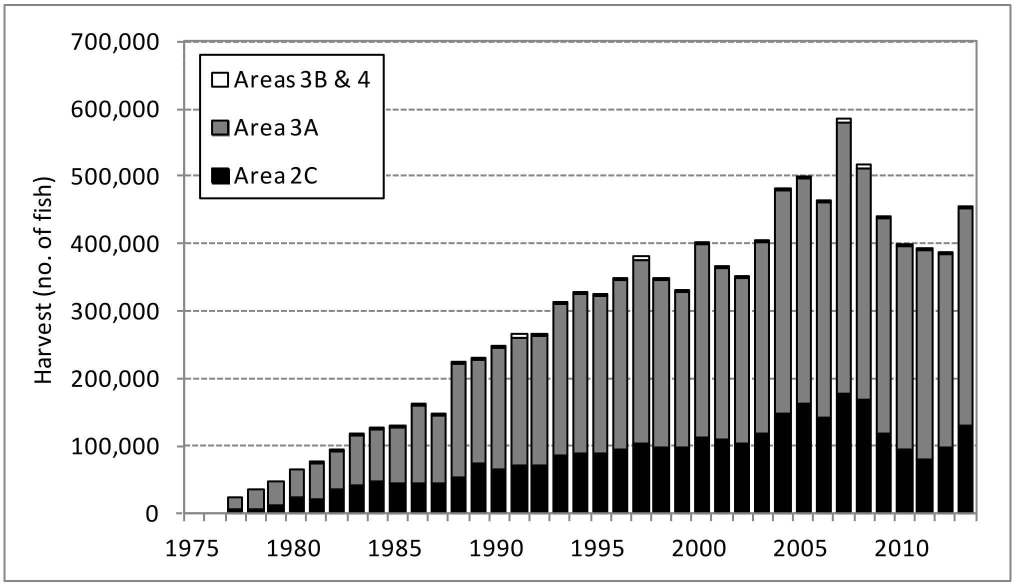

Figure 1. Statewide harvest of halibut (numbers of fish) as estimated by the ADF&G statewide mail survey, 1977-2013.

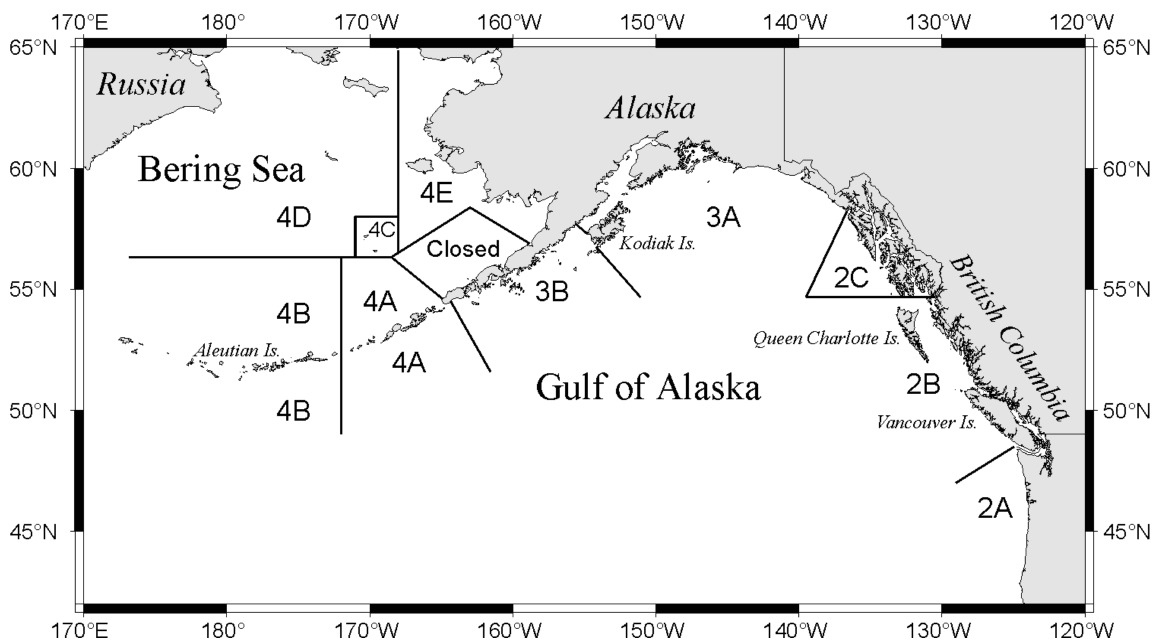

Figure 2. International Pacific Halibut Commission regulatory areas.

As mentioned earlier, the IPHC is responsible for assessing the halibut stock. The assessment includes estimation of total and exploitable biomass, as well as evaluation of alternate harvest strategies. The IPHC conducts a coastwide longline survey annually that provides an index of population density, estimates of age and size structure in the population, and many other types of information. Survey data are combined with catch-at-age and catch rate information from the commercial fishery, as well as removals from other fisheries, in an age and sex-structured model to estimate exploitable biomass.

The stock assessment undergoes constant improvements. The stock assessment procedure underwent a major change in the mid-2000s to reflect a new understanding of halibut movements. As halibut grow, they typically migrate eastward and southward in the North Pacific, counter to the northward and westward drift of eggs and larvae caused by the Alaska Coastal Current and counterclockwise rotation of the Gulf of Alaska gyre. Up until the mid-2000s, it was believed that halibut over 65 cm in length were essentially non-migratory, and the IPHC assessed the halibut stock in each regulatory area separately. Tagging studies in the mid-2000s showed that a substantial portion of the adult stock is migratory. Since 2006 the IPHC has assessed the halibut population as a single stock, combining fishery and longline survey data coastwide in a single age and sex structured model of halibut abundance. The resulting coastwide estimates of biomass are then apportioned to regulatory areas based on the area-specific survey weight per unit effort, weighted by the area of bottom habitat (0-400 fathoms) in each area. There are additional adjustments for harvest taken prior to the average survey date in each area and hook competition by other species.

The exploitable biomass of halibut has been declining since the late 1990s due to a combination of relatively weak recruitments and a long-term decline in size at age. The increasing trend in sport harvest, implementation of catch shares in the commercial fishery, changes in the halibut stock, and ineffective management of the charter fishery led to an intense and prolonged allocation conflict between the commercial and sport charter sectors.

From 2003 to 2013, the charter fisheries in Areas 2C and 3A were managed under Guideline Harvest Levels (GHLs) approved by the Council. The GHLs were established as 125% of the average charter harvest from 1995-1999, and declined in stepwise fashion in proportion to declines in exploitable biomass. Management measures adopted by the Council for the Area 2C charter fishery were inadequate to keep pace with increases in effort and declines in biomass. Over the period 2004-2010, the GHL in Area 2C dropped from 1.432 M lb to 0.788 M lb along with decreases in exploitable biomass. Charter harvest in Area 2C exceeded the GHL every year from 2004 through 2010, with overages ranging from 22 to 115 percent. While the GHL in Area 3A remained steady at 3.65 M lb from 2004 to 2010, charter harvest exceeded the GHL by 1 percent or less in 2004-2006 and by 9.6 percent in 2007.

These allocation conflicts were addressed in two major Council actions. First, the Council approved a limited entry system for halibut charters that was implemented by NMFS in 2011. Limited entry permits were issued to participants that met qualification criteria based on historical (2004 or 2005) and recent (2008) participation. Transferable or non-transferable permits were issued for regulatory areas 2C and 3A based on the number of qualifying boat-trips, and permits were endorsed for a specific number of clients based on past participation. Second, the Council approved a Catch Sharing Plan (CSP) in October 2012 that allocates harvest between the commercial and charter sectors, implements regulations to manage the charter fishery at the beginning of each season, and provide for temporary transfer (lease) of commercial quota for use by individual charter clients in order to harvest halibut in excess of specified bag or size limits placed on the charter fishery. The CSP also establishes the ADF&G charter logbook as the preferred accounting method for charter harvest, and specifies that waste (discard mortality) in the commercial and charter sectors counts toward each sector's allocation. The CSP replaced GHL management effective in 2014.

Four ADF&G programs provide data on recreational halibut harvest in Alaska. The SWHS provides annual estimates of the numbers of halibut harvested and caught in guided and nonguided fisheries. The number of fish released is estimated as the difference between catch and harvest. The logbook program also provides data on the numbers of bottomfish anglers, the numbers of halibut kept and released by the charter sector, and spatial information on harvest and landings. Marine fishery monitoring programs in Southeast and Southcentral Alaska provide information on the sizes of fish harvested in Area 2C and Area 3A. Data from all four of these programs are combined in various ways and provided to federal halibut management agencies for stock assessment, development of harvest policies, and evaluation of annual regulatory alternatives.

This operational plan describes the procedures by which these various data sources are combined on an annual basis to inform federal management agencies for assessment of the halibut stock and management of recreational halibut fisheries. This plan will include only procedures used for routine annual analyses or information requests and will not cover procedures used in occasional special analyses.

OBJECTIVES

The goal of this work is to address routine annual federal information needs for halibut from the sport fisheries in Southeast and Southcentral Alaska. Specific objectives for 2014 are to:

1. Estimate charter (guided) and noncharter (private or unguided) halibut yield (harvest in pounds) in IPHC Areas 2C and 3A for the most recent year with final SWHS estimates, with a relative precision of 15% ($\alpha = 0.05$);
2. Estimate charter halibut yield in Areas 2C and 3A with a relative precision of 10% ($\alpha = 0.05$), using logbook harvest data for the most recent year with complete data;
3. Produce preliminary estimates, or projections, of charter and noncharter halibut harvest, releases, and yield in Areas 2C and 3A for the current year;
4. Estimate charter and noncharter halibut discard mortality in Areas 2C and 3A for the most recent year with complete data;
5. Produce preliminary estimates, or projections, of charter and noncharter halibut discard mortality in Areas 2C and 3A for the current year;
6. Estimate the proportions of charter and noncharter harvest (in numbers of fish) taken in Areas 2C and 3A prior to the average IPHC longline survey date during the current year;
7. Estimate overall sport halibut harvest (charter and noncharter combined) in IPHC Areas 3B and 4 through the most recent year for which SWHS estimates are available; and
8. Produce preliminary estimates, or projections, of overall sport halibut harvest in Areas 3B and 4 for the current year.

METHODS

STUDY DESIGN

As stated previously, this project does not involve any data collection *per se*, but rather relies on other projects and data sources to compile estimates. Final estimates and projections of halibut harvest will be compiled by sector (charter and noncharter) and by halibut reporting areas, and then summed to obtain estimates for each IPHC area. In Southeast Alaska (areas A-H), the halibut reporting areas match the SWHS reporting areas. In Southcentral Alaska, however, some SWHS areas are further divided to better correspond with port sampling data. Specifically, the North Gulf Coast/Prince William Sound (PWS) area, SWHS Area J, is divided into Eastern PWS, Western PWS, and North Gulf Coast. The Area J questionnaire is specifically designed to capture this information. Harvest in Area J is partitioned according to the location where the fish are landed so that average weights estimated from ports of landing are properly matched to the estimated harvests. Similarly, estimates for Cook Inlet (SWHS Area P) are divided into Central Cook Inlet (CCI) and Lower Cook Inlet (LCI). The halibut reporting areas and corresponding ports for each IPHC area are described in Table 1.

FISHERY CREEL SAMPLING

The harvest of charter and noncharter halibut is sampled through onsite fishery monitoring programs in Southeast and Southcentral Alaska. Harvested halibut are measured and average net weight is estimated from weights predicted for each fish using the IPHC length-weight relationship. Charter skippers and noncharter anglers are also interviewed to collect ancillary data on effort, spatial distribution of the harvest, proportions of fish cleaned at sea, etc. Detailed descriptions of sampling and estimation methods for average weight are provided in the operational plans for each project. For purposes of halibut estimation, the end products of this sampling are estimates of average weight (and standard error) by sector (charter and noncharter) and port, and the estimated proportion of noncharter harvest that occurred prior to the average date of the IPHC longline survey.

STATEWIDE HARVEST SURVEY

Estimates of charter and noncharter halibut catch and harvest, along with corresponding standard errors and confidence intervals, are provided through the SWHS. These estimates are summarized by halibut reporting area and IPHC area, and final estimates are typically provided to staff in September of the year following harvest. These charter and noncharter estimates are not summarized in the published SWHS report but are obtained using the same methods.

CHARTER LOGBOOK DATA

Charter logbook data are typically finalized by February or March of the year following harvest. Logbook data are also available on a limited basis during the year, however. For example, for the last several years, logbook data submitted for trips through July have been made available in October for use in harvest projections for the current year. Logbook data have also been used in past years to project the proportion of charter harvest taken prior to the average IPHC longline survey date, calculate the proportion of charter harvest made up of second fish in the bag limit, calculate the average number of anglers per boat trip, etc. Logbook data used for harvest projections and comparisons to the SWHS are also summarized by halibut reporting area (Table 1).

Table 1. Halibut reporting areas and sampled ports corresponding with each IPHC regulatory area.

IPHC Area	Subarea	Sampled Port(s)
2C	Ketchikan (A)	Ketchikan
	Prince of Wales Island (B)	Craig, Klawock
	Petersburg/Wrangell (C)	Petersburg, Wrangell
	Sitka (D)	Sitka
	Juneau (E)	Juneau
	Haines/Skagway (F)	Juneau (proxy)
	Glacier Bay (G2C)	Elfin Cove, Gustavus
3A	Glacier Bay (G3A)	Elfin Cove, Gustavus
	Yakutat (H)	Yakutat
	Eastern PWS (EPWS)	Valdez
	Western PWS (WPWS)	Whittier
	North Gulf Coast (NG)	Seward
	Lower Cook Inlet (LCI)	Homer
	Central Cook Inlet (CCI)	Deep Creek, Anchor Point
	Kodiak (Q)	Kodiak city

DATA ANALYSIS

Objective 1: Estimate charter and noncharter halibut yield in IPHC Areas 2C and 3A for the most recent year with final SWHS estimates.

Yield for each sector Y_g will be estimated for the previous year using final SWHS estimates of the number of halibut kept and average net weight (headed and gutted) estimated from creel sampling. Estimates will be done by subarea (Table 1) and summed to obtain estimates for each IPHC regulatory area 2C and 3A as follows:

$$\hat{Y}_g = \sum_a \hat{H}_{ga} \hat{\hat{w}}_{ga} \tag{1}$$

where

$\hat{H}_{ga}$ = the SWHS estimate of the number of halibut harvested by sector g in subarea a,

$\hat{\hat{w}}_{ga}$ = the estimated mean weight of halibut harvested by sector g in subarea a.

After 2013, charter logbook data will be used for estimation of charter yield. Noncharter yield will continue to be estimated using SWHS data, and charter yield may be calculated using SWHS data for comparison to estimates based on logbook harvest.

The boundary between IPHC areas 3A and 2C bisects the Glacier Bay subarea. Noncharter harvest estimates for the Glacier Bay subarea will be assumed to apply entirely to Area 2C because we have documented very little noncharter harvest taken in IPHC Area 3A and landed in the Glacier Bay subarea. However, charter harvest has been growing in the Area 3A portion of the Glacier Bay subarea. Charter logbook data will be used to apportion the SWHS estimate for the Glacier Bay subarea to waters in Area 3A (G3A) and Area 2C (G2C). For example, harvest in subarea G3A will be estimated as

$$\hat{H}_{G3A} = p_{3A}\hat{H}_{GlacBay} \tag{2}$$

where

$\hat{H}_{G3A}$ = the estimated of the number of halibut harvested by charter anglers in the IPHC Area 3A portion of the Glacier Bay subarea,

p_{3A} = the proportion of charter harvest reported in logbooks landed at sites in the Glacier Bay subarea that was caught in IPHC area 3A,

$\hat{H}_{GlacBay}$ = the SWHS estimate of the number of halibut harvested by charter anglers in the Glacier Bay subarea.

The variance of the charter harvest estimate for subarea G3A will be estimated as

$$var\left(\hat{H}_{G3A}\right) = p_{G3A}^2 var\left(\hat{H}_{GlacBay}\right). \tag{3}$$

Harvest and its variance for subarea G2C will be calculated in the same manner.

The variance of the estimated yield within each IPHC area will be estimated for each sector g using (Goodman 1960):

$$var\left(\hat{Y}_g\right) = \sum_a \left[\hat{H}_{ga}^2\, var\left(\hat{\bar{w}}_{ga}\right) + var\left(\hat{H}_{ga}\right)\hat{\bar{w}}_{ga}^2 - var\left(\hat{H}_{ga}\right) var\left(\hat{\bar{w}}_{ga}\right)\right]. \tag{4}$$

The variance of mean weight for each sector $var(\hat{\bar{w}}_g)$ within each IPHC area will be obtained by Markov Chain Monte Carlo methods using the program OpenBugs[1]. Normal sampling error will be assumed for average weights and harvest estimates. The variances of yield estimates for each sector and IPHC area are also obtained as a check on results from Equation 4 (example code in Appendix A1).

Overall mean weight of the sport harvest (charter and noncharter combined) will be estimated as

$$\hat{\bar{w}} = \hat{Y}/\hat{H} = \sum_g \hat{Y}_g \Big/ \sum_g \hat{H}_g \tag{5}$$

with estimated variance approximated using the Delta method (Seber 1982, pages 7-8):

$$var(\hat{\bar{w}}) \approx \frac{1}{\hat{H}^2}\left[\frac{var(\hat{H}_C)\left[\hat{\bar{w}}_C\hat{H}_N - \hat{Y}_N\right]^2}{\hat{H}^2} + \frac{var(\hat{H}_N)\left[\hat{\bar{w}}_N\hat{H}_C - \hat{Y}_C\right]^2}{\hat{H}^2} + var(\hat{\bar{w}}_C)\hat{H}_C^2 + var(\hat{\bar{w}}_N)\hat{H}_N^2\right], \tag{6}$$

where subscripts *C* and *N* index the charter and noncharter sectors, respectively.

[1] http://mathstat.helsinki.fi/openbugs/HomeFrames.html

These procedures are expected to result in yield estimates for each sector and regulatory area with a relative precision of at least ±15% ($\alpha = 0.05$), based on the relative precision of yield estimates in recent years. The precision of yield estimates is a function of the precision of SWHS harvest estimates and port sampling estimates of average weight.

Estimates of mean weights are derived from creel sampling of the harvest in Southeast and Southcentral regions. True random sampling of harvested halibut is not possible because sampling coverage is incomplete spatially and temporally, and because boats with harvested halibut arrive in port over a prolonged period and often simultaneously. Instead, creel sampling programs attempt to select vessels for sampling in proportion to their share of the harvest. Once a vessel is selected for sampling, all halibut from that vessel are measured.

Before 2011, the variances of mean weights were estimated using formulae for simple random sampling, even though size data were collected from the fishery using a cluster sampling design. These estimates were believed to underestimate the variance of mean weight, and therefore the variance of yield. Since 2011 the standard errors of mean weights for each port and sector have been estimated in the Southcentral Region using a two-stage bootstrap procedure, where the first stage selects days to sample, and the second stage selects vessels. Recent changes to the Southeast Region creel sampling program allow for estimation of standard errors of mean weight using closed form estimators appropriate for cluster sampling (Jaenicke et al. *In prep.*).

Objective 2: Estimate charter halibut yield in Areas 2C and 3A using logbook harvest data for the most recent year with complete data.

Until 2014, ADF&G provided federal halibut management agencies with estimates of sport fishery yield that used SWHS estimates of numbers of fish harvested. Meyer and Powers (2009) evaluated 2006-2008 logbook effort and harvest data through comparisons to an end-of-season survey at the angler-day level, comparisons to SWHS data for single-angler households at the annual level, comparisons to SWHS estimates at the IPHC area and subarea levels, and comparisons to onsite creel survey interview data at the vessel-trip level. These comparisons generally indicated that logbook data was useful for analyses of potential management actions such as changes in bag limits or annual limits. Effort reported in the logbook was similar to effort estimates from the SWHS, but reported harvest was generally higher than the SWHS estimates. Close agreement of logbook data with onsite interview data and data from single-angler households suggests that there may be incomplete reporting of harvest by multi-angler households in the SWHS, though this has not been verified.

The report was presented to the Council and its Scientific and Statistical Committee (SSC) in October 2009. The SSC review was favorable and indicated that use of logbook data offered clear advantages over use of SWHS estimates. The SSC encouraged additional research into the significance of differences between logbook records submitted on time and records submitted late, and indicated that it looked forward to updates of the report as they become available.

Based on the perceived benefits of using logbooks, the Council approved a motion in April 2011 to use charter logbook data to monitor and manage the charter fleet under the CSP. With implementation of the CSP in 2014, ADF&G will estimate charter yield using reported logbook harvest combined with estimates of average weight from creel sampling.

Charter yield Y_C will be estimated for each IPHC area using logbook data from each subarea as:

$$\hat{Y}_C = \sum_a \mathrm{H}_{\mathrm{Ca}}\, \widehat{\bar{w}}_{Ca} \tag{7}$$

where

H_{Ca} = total harvest of halibut reported for clients, crew, and "comps" in subarea a (logbook data),

$\widehat{\bar{w}}_{Ca}$ = the estimated mean weight of charter halibut harvest in subarea a.

Charter halibut harvest will include any reported crew harvest even though crew harvest of halibut is not allowed in Areas 2C or 3A under the CSP. Whether this crew harvest is actually misreported client harvest or illegal crew harvest, the charter sector will be held accountable. The variance will be estimated as

$$var(\hat{Y}_C) = \sum_a \mathrm{H}_{\mathrm{Ca}}^2\, var(\widehat{\bar{w}}_{Ca}). \tag{8}$$

These procedures are expected to provide estimates of charter yield with a relative precision of at least ±10% ($\alpha = 0.05$), based on logbook-based yield estimates from recent years.

Objective 3: Produce preliminary estimates, or projections, of charter and noncharter halibut harvest, release, and yield in Areas 2C and 3A for the current year.

Projections of halibut yield during the current year must be calculated in October for use in the IPHC stock assessment model and to develop IPHC staff recommendations for catch limits. In addition, these preliminary estimates are incorporated into projections of discard mortality (Objective 5) and forecasts of charter yield for the coming year that are used to evaluate alternative charter management measures (not covered in this plan). Estimates must be calculated by sector because harvest in the charter and noncharter sectors is handled differently in terms of catch limits. Although estimates of mean weight are available by October of each year, charter logbook data are incomplete and there is no estimate of the current year's noncharter harvest (in numbers of fish) available from the SWHS. In addition, there is no index from creel sampling that can be used to estimate charter or noncharter harvest inseason.

Charter Harvest:

Methods of projecting charter harvest for the current year have evolved as new types of data have come available. Before 2008, charter harvest projections for the current year were calculated using a the historical ratio between creel survey estimates at major ports and the corresponding SWHS estimates, as well as simple time series methods such as linear forecast, moving averages, and exponentially weighted forecasts. Following improvements to the charter logbook in 2006, it was determined that partial-year logbook data was superior to time series forecasts. From 2008 to 2011, charter harvest projections for Areas 2C and 3A were made by applying the relative change in the logbook harvest since the previous year to the SWHS harvest estimate from the previous year (logbook ratio method). Only logbook data through July of each year were available when projections were made in October. Although the proportion of reported charter harvest through July was relatively constant, the relationship between reported logbook harvest and estimated harvest from the SWHS was not constant from year to year. Once a few years had passed with paired logbook and SWHS estimates, a regression approach was used to make preliminary estimates for 2012 and 2013 (Meyer 2012). These projections were based on zero-intercept regressions of partial-year logbook data (through July 31) on SWHS estimates. The regressions were done by subarea and summed to provide projections for each IPHC area.

Beginning in 2014, the ADF&G logbook is the preferred data for counting charter harvest, and there is no longer a need to project SWHS estimates of charter harvest. The proportion of harvest taken through July is relatively consistent among years, but there appear to be weak trends in some subareas. Trends in the proportion of harvest through July would add systematic error to predictions based on linear models such as regression. A simple and flexible approach is to simply expand the harvest through July to an annual total based on a forecast of the proportion of harvest through July.

Charter harvest for the current year will be projected for each subarea using:

$$\hat{H}_{Ca} = \mathrm{H}_{\mathrm{Ja}}/\hat{p}_{Ja} \tag{9}$$

where

H_{Ja}	= total harvest of halibut reported in logbooks for clients, crew, and "comps" through July 31 in subarea a,
$\hat{p}_{Ja}$	= the simple exponential time series forecast of the proportion of charter harvest taken through July 31 of the current year in subarea a.

Charter operators have reported small amounts of crew harvest from both IPHC areas during years or times when crew harvest was prohibited by state Emergency Order or federal regulations. The reported harvest through July 31 (H_{Ja}) will be calculated for projections in October. This number may be slightly low due to logbook pages not yet filed. From 2011 to 2013, the reported harvest thru July 31, as calculated in October, was an average of 1.0% lower in Area 2C and 0.8% lower in Area 3A than the final values based on complete logbook data. This is a small error, but would typically result in an underestimate and would be magnified when harvest through July 31 is expanded. Therefore, this number may be inflated by the recent average to account for late logbooks unless logbook data entry staff are confident that late reporting will be negligible.

The variance of projected harvest within each subarea will be estimated as

$$var(\hat{H}_{Ca}) = \mathrm{H}_{\mathrm{Ja}}^2\, var\left(1/\hat{p}_{Ja}\right) = \mathrm{H}_{\mathrm{Ja}}^2\, \frac{1}{\hat{p}_{Ja}^4} var\left(\hat{p}_{Ja}\right). \tag{10}$$

The harvest proportions for each subarea $\hat{p}_{Ja}$ will be forecast using a simple exponential smoother in SAS Proc ESM (SAS 2011). The simple smoother is appropriate because the time series is short and has no strong trend in any subarea. SAS procedure output provides the forecasts and their standard errors, which will be used to calculate $var\left(\hat{p}_{Ja}\right)$.

Projected charter yield for each IPHC area will be estimated using Equation 7, replacing the final logbook harvest in each subarea H_{Ca} with projected values $\hat{H}_{Ca}$. The variance will be estimated as

$$var(\hat{Y}_C) = \sum_a \hat{H}_{Ca}^2\, var(\hat{\bar{w}}_{Ca}) + var\left(\hat{H}_{Ca}\right)\hat{\bar{w}}_{Ca}^2 - var\left(\hat{H}_{Ca}\right)var(\hat{\bar{w}}_{Ca}). \tag{11}$$

This method was tested by projecting 2013 final charter logbook harvest for IPHC areas 2C and 3A and compared to final 2013 logbook data (Table 2). The exponential smoother provided reasonable fits to observed proportions of harvest through July 31 (Figure 3). The charter harvest projections were 0.2% below the final logbook harvest (in numbers of fish) for Area 2C, and 1.8% below the final logbook harvest for Area 3A. This is a substantial reduction in error compared with prior projections of SWHS estimates, which ranged from -23% to +16% for Area 2C and from -13% to +11% for Area 3A during the years 2001-2013. The relative precision (with $\alpha = 0.05$) of projected harvests were 3.7% for Area 2C and 3.1% for Area 3A. Therefore, final logbook harvests were well within the confidence intervals of the projections in 2013.

Table 2. Example of projected charter harvest for 2013 using logbook data through July 31 and forecasts of the proportion of harvest taken through July 31.

IPHC area	Subarea	Harvest thru July H_{Ja}	Forecast $\hat{p}_{Ja}$	SE ($\hat{p}_{Ja}$)	Projected Harvest $\hat{H}_{Ca}$	SE ($\hat{H}_{Ca}$)	Final Harvest H_{Ca}	Projection Error[a]
Area 2C	A-Ketch	4,134	0.613	0.031	6,742	338	6,712	0.4%
	B-POW	11,392	0.661	0.013	17,222	345	16,814	2.4%
	C-Pburg	1,216	0.596	0.030	2,039	104	2,107	-3.2%
	D-Sitka	11,620	0.671	0.030	17,321	767	17,268	0.3%
	EF-Jun	3,852	0.573	0.035	6,718	407	6,487	3.6%
	G-GlacB	4,738	0.583	0.034	8,131	468	8,880	-8.4%
	Total 2C	36,952			58,172	1,103	58,268	-0.2%
Area 3A	G-GlacB	1,093	0.663	0.125	1,649	312	1,431	15.2%
	H-Yak	1,989	0.584	0.040	3,403	235	3,888	-12.5%
	EPWS	4,319	0.727	0.059	5,944	482	5,708	4.1%
	WPWS	4,342	0.666	0.052	6,518	504	6,024	8.2%
	NGulf	32,866	0.685	0.027	47,945	1,903	47,551	0.8%
	LCI	54,892	0.703	0.021	78,045	2,331	80,646	-3.2%
	CCI	44,892	0.790	0.016	56,838	1,137	58,567	-3.0%
	QR	6,493	0.502	0.020	12,929	502	13,401	-3.5%
	Total 3A	150,886			213,271	3,353	217,216	-1.8%

[a] Projection error is calculated as (projection-final)/final × 100.

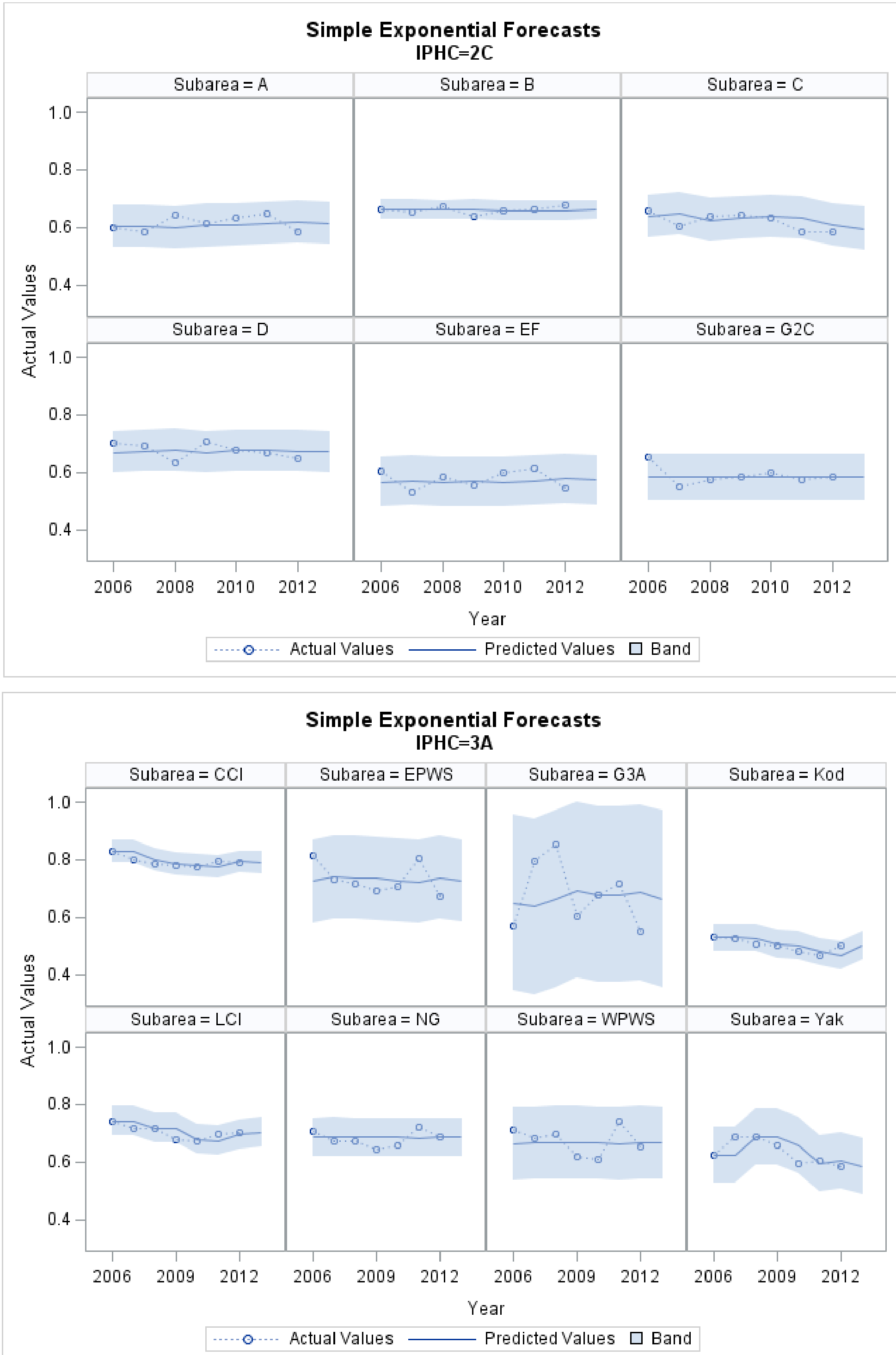

Figure 3. Example of a simple exponential smoother (SAS Proc ESM) applied to forecast the proportion of charter halibut harvest that occurred through July 31 of each year, in subareas of IPHC Area 2C (upper) and Area 3A (lower). The shaded regions represent 95% confidence bands for the predicted (smoothed) values in 2006-2012 and the 2013 forecast.

Noncharter Harvest:

Lacking any inseason measure of harvest in either region, time series methods will continue to be used to project noncharter harvest for the current year. In October 2012 the Council's SSC recommended using ARIMA models. Noncharter yield Y_N will be projected using the combination of time series forecasts of the number of fish harvested and mean weights from the current year as follows:

$$\hat{Y}_N = \sum_a \hat{H}_{Na} \hat{\bar{w}}_{Na} \tag{12}$$

where

$\hat{Y}_N$ = the projected noncharter halibut yield,

$\hat{H}_{Na}$ = the time series forecast of noncharter halibut harvest for subarea a, and

$\hat{\bar{w}}_{Na}$ = the estimated mean weight of halibut harvested by noncharter anglers in subarea a.

Variance of the yield estimate will be estimated using Equation 4, and confidence intervals will be produced assuming a normal distribution..

Appropriate time series models will be identified using the Box and Jenkins (1976) procedure for auto-regressive integrated moving average (ARIMA) models as described in Chapter 7 of the SAS/ETS User Guide (SAS 2011). Models will be selected for each subarea based on examination of residuals and the Akaike Information Criteria corrected for small sample sizes.

Because time series methods rely on historical patterns and trends, forecast errors can occur from changes in factors that affect the harvest, such as the economy, bag and size limits for the halibut fishery, targeting of other marine species, etc. Changes in bag limits are much more likely for the charter sector because it is managed under a GHL, while the unguided sector has no annual harvest cap.

Objective 4. Estimate charter and noncharter halibut discard mortality in Areas 2C and 3A for the most recent year with complete data.

The IPHC strives to document and include all fishery removals in the annual stock assessment. Until now, the IPHC's annual estimates of fishery removals have included commercial harvest, longline survey harvest, estimates of bycatch mortality in non-halibut fisheries, waste in the halibut longline fishery (mortality of sublegal fish released and fish that die on lost or abandoned gear), subsistence harvest, and sport harvest. Bycatch and waste are estimated separately for halibut $\geq$ 26 inches (O26) and halibut < 26 inches in length (U26). Only the O26 discard mortality is included in allocations to the commercial and charter sectors. Release mortality in recreational fisheries has not been documented, primarily due to the lack of information on the number and sizes of released fish. Interest in release mortality has intensified with implementation of charter size and bag limit restrictions and changes to commercial observer coverage in recent years.

In April 2012 the IPHC sent a letter asking ADF&G (as well as other agencies coastwide) to develop and implement data collection programs to permit estimation of discard mortality in the recreational fishery. The department responded that it presently lacks the fiscal resources to implement sampling of released fish, but will use modeling based on available data and assumptions to produce the best possible estimates of release mortality in recreational halibut fisheries.

The department undertook this type of modeling effort in 2007 (Meyer 2007), using available SWHS estimates of the numbers of released fish, an assumed mortality rate based on hook use data, and modeling of the size distribution of released fish. The approach was reviewed by the NPFMC's Scientific and Statistical Committee. Although modeling of the size distribution of released fish relied on strong assumptions, the SSC concluded that the approach provided "reasonable estimates of discard mortalities for different gear types based on existing literature."[2] The following modeling approach is similar to the one used in 2007.

Release mortality R will be calculated for each sector (charter and noncharter) and subarea using the basic equation:

$$R(lb) = \hat{N} \cdot DMR \cdot \hat{\bar{w}} \qquad (13)$$

where

$\hat{N}$ = the estimated number of fish released from SWHS or logbook,

DMR = the assumed mortality rate due to capture, handling, and release, and

$\hat{\bar{w}}$ = the estimated mean net weight (in pounds) of released fish.

Estimated Number of Released Fish:

Estimates of the number of released halibut are available from the SWHS and from logbooks. Consistent with the Council's intentions with respect to charter harvest, logbook data will be used for release mortality estimates for the charter sector beginning in 2014. The SWHS release estimates will be used for all estimates for the noncharter sector, and to finalize release mortality estimates for the charter sector for 2013. Now that discard mortality is included in the charter allocation, there is a strategic incentive for charter operators to underreport numbers of released fish. Logbook, SWHS, and creel sampling data will be examined annually to look for changes that may indicate underreporting.

Discard Mortality Rate:

There are no published estimates of the mortality rate of halibut or closely related species caught and released in a recreational fishery. Meyer (2007) derived mortality rates using hook type (circle versus other) as the primary factor. The rates were derived as weighted estimates of a 3.5% mortality rate for halibut released on circle hooks and a 10% mortality rate for halibut released on all other hook types, weighted by the proportions of released fish caught on each hook type. The 3.5% rate was the midpoint of Peltonen's (1969) best estimate of 2-5% for 75-119 cm halibut caught on longline gear with J-hooks, tagged, and held in cages. This is the mortality rate the IPHC assumes for halibut caught on longline gear and released in excellent

[2] SSC report, page 5, October 1-3, 2007 (http://www.fakr.noaa.gov/npfmc/PDFdocuments/minutes/SSC1007.pdf).

condition (Kaimmer and Trumble 1998, Williams 1998). Because most sport-caught halibut are caught on circle hooks and played for a short period of time, use of this rate for the sport fishery was considered to be conservative. The 10% mortality rate for halibut caught on hook types other than circle hooks was assigned based on results of a literature review of release mortality in a variety of marine fishes. The weighting factors for mortality on each hook type were obtained using creel survey data on the numbers of halibut released from circle and other hook types collected in Southeast and Southcentral regions in 2007. Hook type data were also collected in 2008 in Southeast, and every year since 2007 in Southcentral.

Mortality rates were estimated for each sector and subarea of Areas 2C and 3A and then weighted by the proportions of released fish in each IPHC area (SWHS estimates) to derive overall mortality rate estimates for each sector and IPHC area. The calculated rates were then rounded up as a precautionary measure to account for other factors such as rough handling or multiple recaptures of the same fish. These derived estimates were 5% for Area 3A charter-caught halibut, 6% for Area 2C charter and Area 3A noncharter, and 7% for Area 2C noncharter halibut. Mortality rates will be re-evaluated using hook data from more recent years, along with logbook data (charter) or SWHS estimates (noncharter) for the weighting among subareas.

Estimating Mean Net Weight:

There are no data available on the lengths of individual released halibut in sport fisheries in Alaska. However, the creel sampling program in Southeast Alaska has collected data on the number of released halibut by size category in Area 2C since 2012, the first year of the reverse slot size limit. The size categories in 2013, under a U45-O68 reverse slot limit were (1) ≤ 45 inches, (2) greater than 45 but less than 68 inches, and (3) ≥ 68 inches. For 2014 the reverse slot limit was changed to U44-O76 and size classes were adjusted accordingly. No size class information is collected in Area 3A.

Since size data are not available on individual fish, reasonable estimates of the average weight of released fish for each sector in each IPHC area and subarea will be derived using a modeling approach similar to Meyer (2007). Two slightly different approaches will be used to estimate average weight, depending on available data. For the noncharter sector in Areas 2C and 3A and charter sector in Area 3A, where no size data are available, the mean weight of released fish will be obtained entirely through modeling. First, a logistic curve will be constructed to represent the probability of retaining a halibut as a function of its length, or p_L:

$$p_L = \frac{p_\infty}{1 + \exp\left(-\kappa(L - \gamma)\right)} \tag{14}$$

where

p_∞ = the theoretical maximum retention probability ($p_\infty \leq 1$),

κ = a slope parameter, and

L = length to the nearest inch (for compatibility with size limits), and

γ = the length at the inflection point of the curve.

This retention probability will be used to infer the average weight of released fish in each sector, IPHC area, and subarea. First the total harvest at length H_L (in numbers of fish) will be calculated as the product of the harvest estimate from either the logbook (charter) or SWHS (noncharter) and the estimated length composition of the charter or noncharter harvest from creel sampling. Catch at length, which includes halibut kept and released, will be estimated as H_L/p_L, and the number of fish released at length N_L will be obtained by subtraction:

$$N_L = \left(\frac{H_L}{p_L}\right) - H_L \quad = \quad H_L\left(\frac{1}{p_L} - 1\right) \tag{15}$$

Mean weight of U26 and O26 released halibut will then be calculated separately for all fish < 26 inches and fish ≥ 26 inches in length as:

$$\widehat{\bar{w}} = \frac{1}{N_L}\sum_{L} N_L \widehat{\bar{w}}_L \tag{16}$$

where $\widehat{\bar{w}}_L = 6.921 \times 10^{-6} L(cm)^{3.24}$, the IPHC length-weight relationship (Clark 1991).

Without length data on released halibut, the p_L curve (Equation 14) cannot be fit in the usual manner. Instead, the curve will be fit to two empirical data points derived from fisheries for other species where both retained and released fish were measured (or lengths were estimated). These data indicate a general pattern where an average of about 22% of the catch was retained at the 10th percentile for length in the harvest, and an average of 83% of the catch was retained at the 90th percentile for length of retained fish (Figure 4). These percentages at the 10th and 90th percentiles for length will be used as targets to fit the logistic curve. The κ and γ parameters will be obtained using Excel Solver by minimizing the sum of the absolute values of the relative difference between the predicted and target proportions at the 10th and 90th percentiles, under the constraint that the predicted number of released fish ($\sum N_L$) equals the estimate of released fish from the logbook (charter) or SWHS (noncharter). Lacking any size data, the asymptote parameter p_∞ will be fixed arbitrarily at 0.95 to reflect the possibility that 5% of exceptionally large fish are released (some anglers release large fish out of concern for meat quality or conservation of large females). Once the logistic curve is fit, the length frequency and average weight of released fish is calculated using Equation 15. Figure 5 provides an example from the Homer fishery (Lower Cook Inlet) fit to data for 2013.

The logistic curve that predicts the probability of keeping a fish based on its size cannot be used for all charter-caught halibut in Area 2C because regulations require that all halibut > 44 inches and < 76 inches be released. However, size class information described earlier is available for halibut released in the Area 2C charter fishery. This information can be integrated with the modeling approach to improve the estimates of average weight. First, the observed proportions of released fish in each size category will be used to apportion the total estimated number of releases by size. The logistic curve procedure described above will be used to estimate mean weight of released halibut ≤ 44 inches in length. This is possible because in prior years, the predicted percentage of halibut kept at 44 inches was close to the maximum of 0.95. For halibut > 44 inches and < 76 inches, and halibut ≥ 76 inches, the mean weight will be assumed to equal the average weight of halibut in this length range in 2010, the last year for which there was no size limit.

Because the logistic modeling is done as a function of length, it allows for calculations of release mortality for fish less than 26 inches (U26) and fish ≥26 inches (O26). This will allow for equal treatment of these components in the sport, commercial, and bycatch sectors.

The estimates of mean weight using these methods may be conservative (high). The numbers of released fish are predicted directly from the numbers of harvested fish using the curve representing the proportion of catch retained. Therefore, the minimum size of released fish cannot be less than the minimum size of harvested fish. Undoubtedly, some halibut are released that are smaller than the smallest halibut retained and measured. Therefore, use of the logistic curve may underestimate the numbers of U26 fish released and overestimate their average weight. Fixing p_∞ at 0.95 may result in underestimation or overestimation of the average weight of released fish, but this would likely be a small effect because relatively few exceptionally large fish would be released.

Without ample size data on individual released fish, this modeling approach is approximate and depends on a number of assumptions. The methods, assumptions, hook type data, and literature on survival rates will be reviewed annually and revisions will be made as appropriate in order to provide the most realistic estimates of release mortality possible. In addition, changes in annual management measures, such as size limits, may force revision of calculation methods.

Objective 5: Produce preliminary estimates, or projections, of charter and noncharter halibut discard mortality in Areas 2C and 3A for the current year.

These estimates will use the same methods as for Objective 4, replacing final estimates of harvest and release (in numbers of fish) with preliminary estimates for the current year. Preliminary estimates of harvest and release for the current year will be obtained as described under Objective 3.

Objective 6. Estimate the proportions of charter and noncharter harvest (in numbers of fish) taken in Areas 2C and 3A prior to the average IPHC longline survey date during the current year.

The IPHC conducts a longline survey of the halibut population from Washington to the Bering Sea. Weight per unit effort (WPUE) of fish over 32 inches (O32) is used as an index of exploitable biomass in the stock assessment model. The WPUE of O32 fish, when weighted by the area of halibut habitat and adjusted for other factors, is also used to apportion coastwide estimates of exploitable biomass to regulatory areas. The IPHC adjusts the WPUE index for fishery removals that occur before the middle of the survey (Webster and Stewart 2014).

Therefore, the IPHC annually requests estimates of the proportions of sport harvest taken before the average date of the longline survey in Area 2C and Area 3A. The average dates of the longline survey are provided by the IPHC after the surveys are complete. The IPHC has stated that there is no need to partition reported harvest by size class or base the estimated proportions on biomass units (R. Webster., IPHC, personal communication). Therefore, estimates of the proportion of harvest will be based on numbers of fish, assuming that the size composition of the harvest is constant over the course of the fishing season.

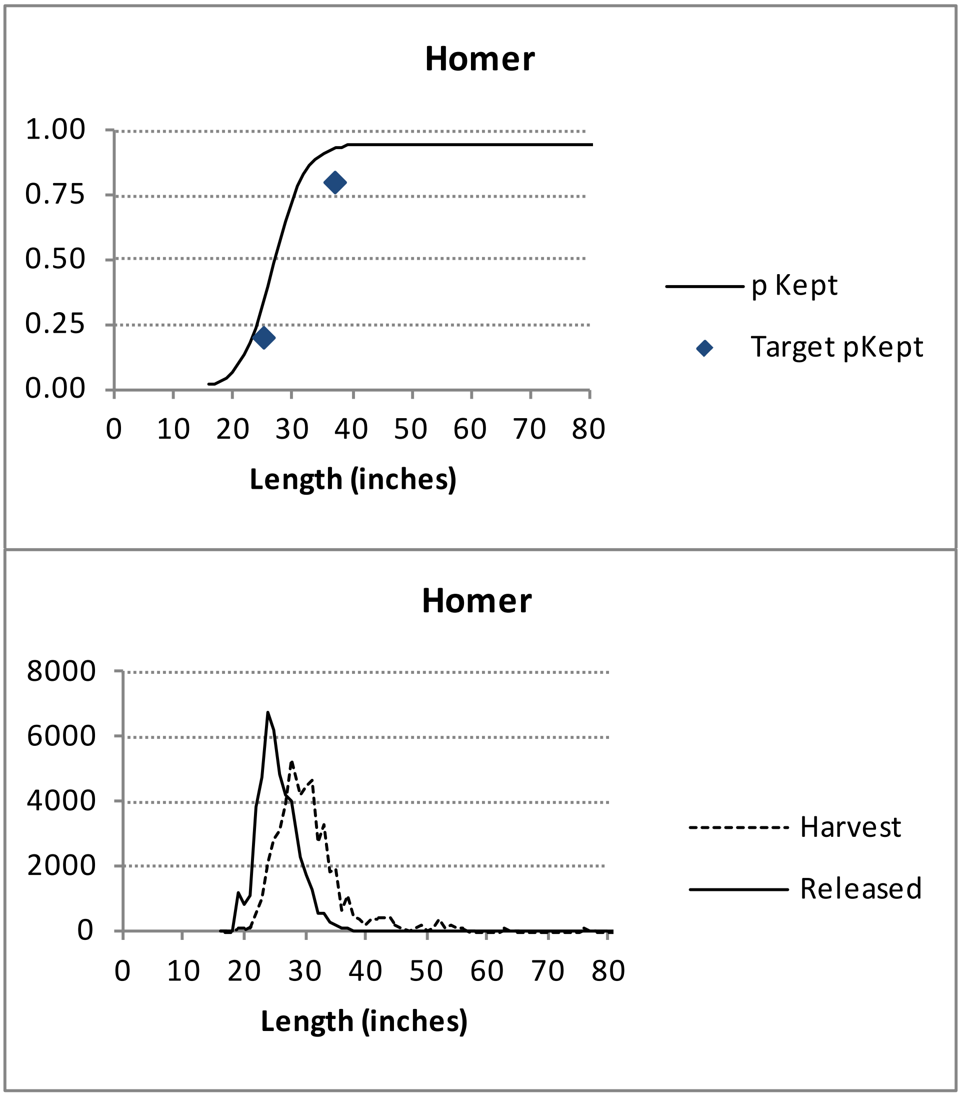

Figure 4. Example of using 2013 length data from halibut harvested at Homer to predict the length frequency of released halibut. In the upper figure, a logistic curve was fit to empirical points representing 20% retention at the 10th percentile for length (25 inches) and 80% retention at the 90th percentile for length (37 inches), subject to the condition that the predicted number of released fish (sum over length frequency in the lower figure) equals the preliminary estimate of released fish for 2013. The mean weight of released fish is calculated from the release length frequency in the lower figure using the IPHC length-weight relationship.

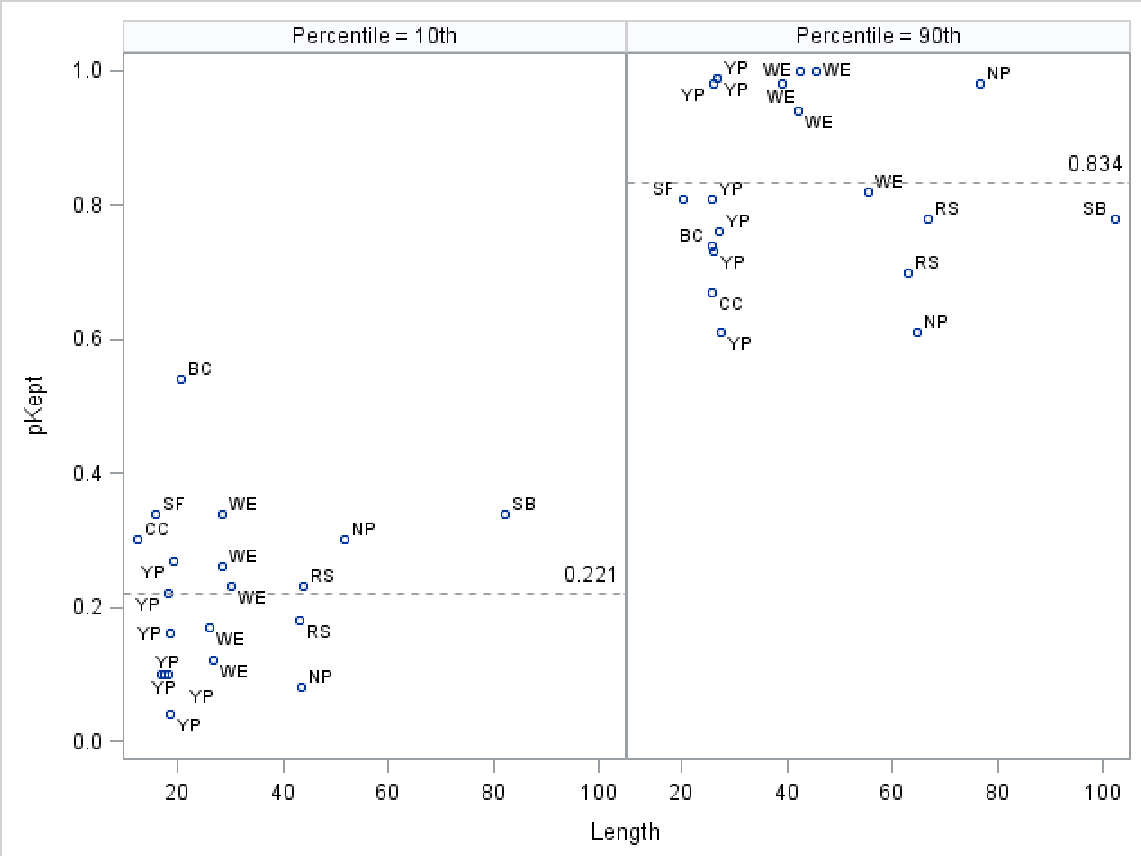

Figure 5. Estimates of the proportions of the catch that was kept (pKept) corresponding with the 10th and 90th percentiles for length (cm) in the harvest. Mean values for pKept are 0.221 at the 10th percentile, and 0.834 at the 90th percentile, indicated by dotted reference lines. Data are from creel surveys where length of released fish was recorded from measurements or angler estimates. Data were included for fisheries without size limits, or fisheries where the minimum size limit was well below the smallest fish retained (didn't have a significant effect on the proportions kept). Species include red snapper Lutjanus *campechanus* (RS), striped bass *Morone saxatilis* (SB), northern pike *Esox lucius* (NP), yellow perch *Perca flavacens* (YP), walleye *Sander vitreus* (WE), black crappie *Pomoxis nigromaculatus* (BC), sunfish *Lepomis* spp. (SF), and channel catfish *Ictalurus punctatus* (CC). Sources include Chapman (2001), Donaldson et al. (2002), Jensen (2012), Jensen (2013), Meerbeek (2006), Minnesota DNR (no date), and Pelham (2004).

The charter and noncharter proportions of harvest prior to the average survey date will be estimated using different methods. Because complete charter logbook data are unavailable in October when the estimation must be done, the charter before-survey (BS) harvest proportion will be estimated for each IPHC area as the mean of the logbook proportions of harvest prior to that date from the three previous years. Over the past five years, this projection method has produced estimates that were within 3 percentage points of the final logbook estimates in both IPHC areas. This level of error is more than adequate for use in adjusting the survey WPUE because the sport harvest represents a relatively small portion of total removals prior to the survey (Dr. Ray Webster, IPHC, personal communication). This projection method is likely to produce reasonable estimates as long as management actions are not taken that affect the timing of the charter harvest. In the event of a regulation change that affects harvest timing, creel interview data may be used to estimate the charter before-survey proportion. For the noncharter fishery, creel survey interview data are the only source of information on the timing of harvest. The marine fishery monitoring programs in Southeast and Southcentral regions will provide estimates of the BS proportions of noncharter harvest for each port, with the procedures for estimation described in those programs' respective operational plans (Failor 2013, Jaenicke et al. *In prep.)*. The noncharter proportions for each port will then be weighted by the projected noncharter harvest for each halibut reporting area (from Objective 3) to estimate the overall proportion for each IPHC area.

Finally, the projected BS proportions for the sport fishery as a whole will be computed as a weighted mean of the charter and noncharter BS proportions, using projected charter and noncharter harvests (from Objective 3) as weighting factors. Because the IPHC will use these point estimates only as one component of an adjustment to survey WPUE, no effort will be made to evaluate the uncertainty of these estimates and no values are established for desired precision.

Objective 7: Estimate overall sport halibut harvest (charter and noncharter combined) in Areas 3B and 4 through the most recent year for which SWHS estimates are available.

These estimates will be obtained by summing site-specific halibut harvest estimates from SWHS Area R (Naknek River Drainage-Alaska Peninsula). The site-specific estimates are found in detailed harvest printouts available on the ADF&G Docushare site. Each site code will be classified into IPHC Area 3B or Area 4, and estimates summed by area. Charter and noncharter harvest will be combined because the numbers of survey responses are typically insufficient to generate reliable estimates for each sector (K. Sundet, ADF&G RTS, personal communication), and because there are no separate catch limits or regulations for the charter sector in these areas. Variances of harvest estimates are not available at the site specific level, and will not be presented to the IPHC. The estimates will be presented in terms of the numbers of fish, rather than in biomass units, because there is no sampling in either area and no estimates of average weight.

Objective 8: Produce preliminary estimates, or projections, of overall sport halibut harvest in Areas 3B and 4 for the current year.

Preliminary harvest projections for the current year are needed by the IPHC for inclusion in the current year's stock assessment model. The total sport harvest (charter and noncharter combined) will be projected in numbers of fish using the Box and Jenkins (1976) ARIMA time series method as described under Objective 3. The time series of available harvest estimates stretches back to 1991 for both areas. Harvest has been relatively small, on the order of a few thousand fish in each area, and highly variable from year to year. Because of this variability, the Box and Jenkins procedure typically finds no significant autoregressive or moving average components and identifies a naïve model (forecast = previous year's harvest) as the best.

SCHEDULES AND DELIVERABLES

Most of the estimates and projections in this plan are intended to be delivered on an annual basis. Many of the objectives address information needs for the annual halibut stock assessment by the IPHC. These elements are delivered in an annual letter to the IPHC, usually sent in late October or early November. Finalized harvest estimates for the previous year are typically posted on the NPFMC website (http://www.npfmc.org/halibut-charter-management) and presented at the October or December NPFMC meeting.

Reports documenting final SWHS-based estimates of halibut harvest and yield, length composition, and spatial distribution of harvest are prepared on an intermittent basis in cooperation with staff from Region 1 and Region 2. Halibut sampling and estimation is supported by General Funds, so there are no Federal Aid contract requirements for reports. These reports have been published as ADF&G Special Publications or as NOAA grant reports in recent years. The next version of this report will include final harvest estimates for the years 2008-2013 and will likely be published as an ADF&G Special Publication.

The estimation and projection methods documented in this plan will also be incorporated, as needed, into evaluations of alternative harvest strategies identified for analysis by the North Pacific Fishery Management Council. It is not possible at this time to know which management alternatives will be selected for analysis, but analysis will proceed with guidance from the project biometrician and review by the Council's SSC.

Table 3. Approximate annual timeline of estimation and reporting tasks associated with halibut.

Time frame	Task
Jul-Aug	Revise operational plan, including review of estimation methods and data inputs.
	Assist NPFMC and NMFS staff with analyses related to pending halibut actions.
	Review SWHS preliminary estimates of halibut harvest for 2011.
	Finalize and present 2011 harvest estimates to NPFMC.
Sep-Oct	Finalize previous year's harvest and release mortality estimates and post to NPFMC website.
	Calculate harvest and release mortality projections for current year.
	Estimate charter and noncharter harvest prior to the mean IPHC survey date.
	Submit annual letter to IPHC containing information needed for stock assessment.
	Meet with Halibut Charter Implementation Committee to present recent estimates and solicit candidate management measures to analyze for the coming year.
	Commence analysis of management measures, including harvest forecasts under each alternative scenario.
Nov-Dec	Finalize analysis of management measures. Attend IPHC Interim meeting to present harvest information and obtain likely harvest targets.
	Attend Council meeting to present finalized harvest estimates, harvest projections for the current year, and analysis of management alternatives.
Jan	Attend IPHC Annual Meeting, present sport fishery information and analysis of management measures.
Feb-Jun	Project planning, report completion.

RESPONSIBILITIES

Scott Meyer (Fishery Biologist):

Primarily responsible for coordination of operational planning, development of methods, coordination and compilation of data components, producing estimates, and reporting.

In coordination with the Commissioner's office, serves as principal Sport Fish Division contact to the IPHC, NPFMC, and NMFS on technical issues concerning halibut catch estimation and other analyses needed for allocation and management of halibut. Reviews ADF&G marine fishery monitoring programs to ensure collection of appropriate data for federal assessments and management, produces estimates of recreational halibut harvest and analyzes alternative management measures for the charter fishery. Presents sport fishery information at regular meetings of the NPFMC and IPHC, and coordinates responses to routine information requests from various stakeholders.

Adam Craig (Biometrician):

Serves as primary consulting biometrician, providing technical advice and assistance with methods of estimation, forecasting, and modeling. Assists with preparation of the operational plan as well as letters, reports, or presentations of halibut harvest estimates and projections.

Michael Jaenicke (Fishery Biologist), Diana Tersteeg (Research Analyst), and Barbi Failor (Fishery Biologist)

Oversee collection of halibut fishery data from the Southeast and Southcentral region catch monitoring programs. Provide raw and summarized data as needed, and provide estimates of average weight and the proportion of harvest taken prior to the average survey date, by port. Assist with final report preparation, attend meetings of federal management agencies, and assist with presentation of data.

Kathrin Sundet (Research Analyst):

Provides annual summaries of SWHS estimates of charter and noncharter sport halibut harvest (and standard error) by halibut reporting area. May provide special analyses or summaries as part of broader efforts to evaluate the quality of logbook or mail survey estimates.

Robert Powers (Research Analyst):

Provides harvest summaries and other analyses of charter logbook data.

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APPENDIX A

Appendix A1. Sample OpenBugs code and results of estimation of the standard error of average weight and yield for charter and noncharter sectors in IPHC Area 2C (Objective 1).

Stratified Halibut Mean Weight: Area 2C, 2013
weighted by estimated harvest at individual ports
Xse are bootstrap standard errors
N=weighting variable, subject to meas errors Nse (harvest in this case),
X=variable of interest, subject to meas errors Xse (mean length and mean weight in this case)
H=number of strata (ports)

```
model {
 for (h in 1:H) {
   N[h] ~ dnorm(0,1.0E-24)
   X[h] ~ dnorm(0,1.0E-12)
   Nhat[h] ~ dnorm(N[h],Ntau[h])
   Xhat[h] ~ dnorm(X[h],Xtau[h])
   Ntau[h] <- 1 / Nse[h] / Nse[h]
   Xtau[h] <- 1/Xse[h]/Xse[h]
   }
 X.weighted <- inprod(N[],X[])/sum(N[])
 Yield <- inprod(N[],X[])
}
```

Initial Values

```
H=6
list(X=c(20,20,20,20,20,20),N=c(10000,10000,10000,10000,10000,10000))
```

Data and Results

```
MeanWeight,charter,2013
list(H=6, Xhat=c(14.01799,12.16518,20.29040,12.56331,12.48471,20.85871),
Xse=c(.54804,1.06416,1.71054,0.46828,0.63630,1.57792),
Nhat=c(4975,11074,4168,17669,6821,7968),
Nse=c(572,938,568,1097,768,795))
```

	mean	sd	MC_error	val2.5pc	median	val97.5pc	start	sample
X.weighted	14.47	0.4216	0.001867	13.66	14.47	15.3	101	49900
Yield	762200.0	36620.0	157.8	691800.0	761700.0	834700.0	101	49900

```
MeanWeight,private,2013
list(H=6, Xhat=c(15.52289,14.37158,20.24534,13.52849,12.53172,27.46735),
Xse=c(.87268,1.75072,1.33216,2.65576,.55682,2.28320),
Nhat=c(13689,13674,17159,5285,16308,11963),
Nse=c(2048,1764,1741,675,1757,1333))
```

	mean	sd	MC_error	val2.5pc	median	val97.5pc	start	sample
X.weighted	17.43	0.6538	0.002882	16.17	17.43	18.72	101	49900
Yield	1.36E+6	84730.0	352.7	1.197E+6	1.359E+6	1.528E+6	101	49900